Cut-and-Paste Editing of Multiresolution Surfaces

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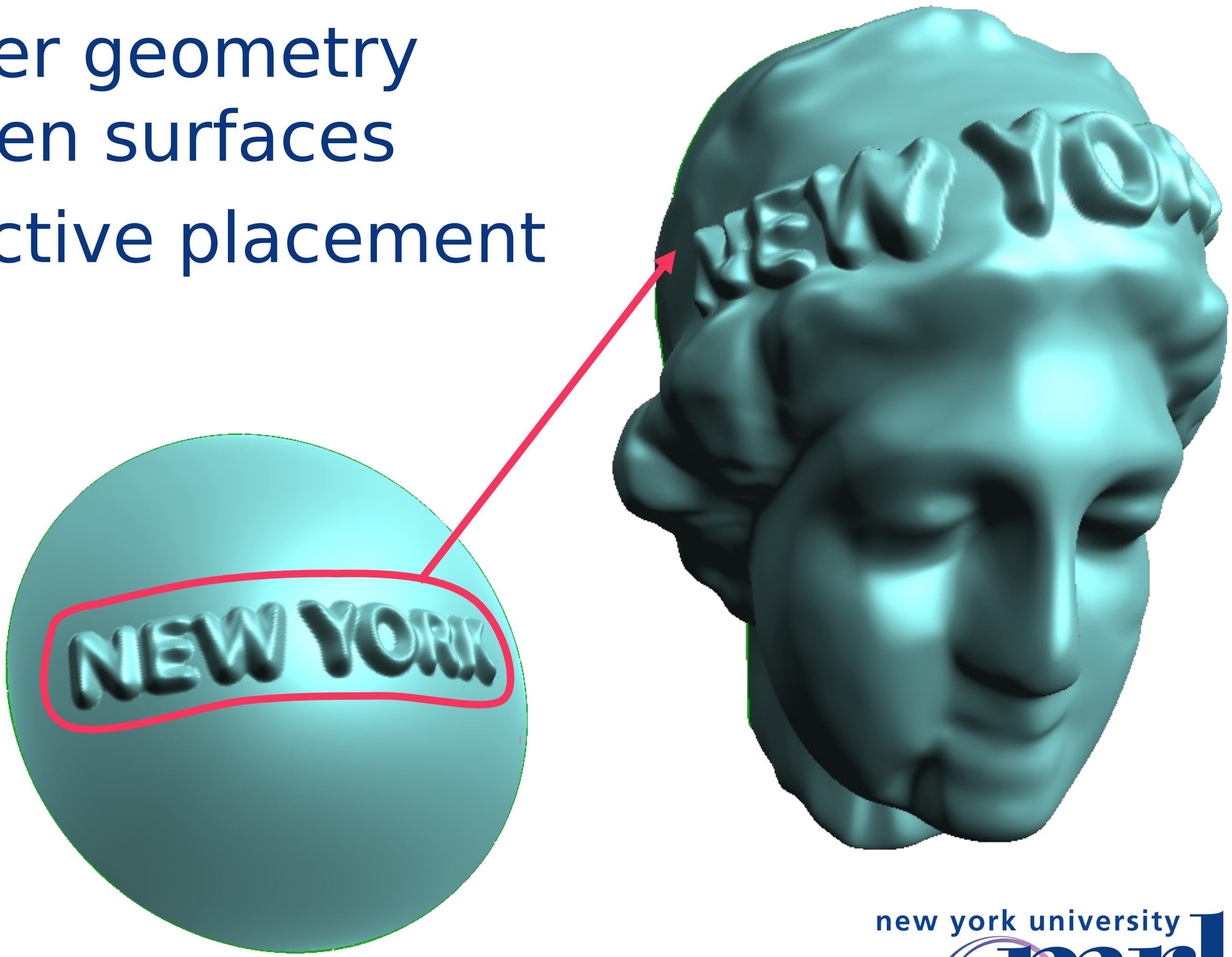
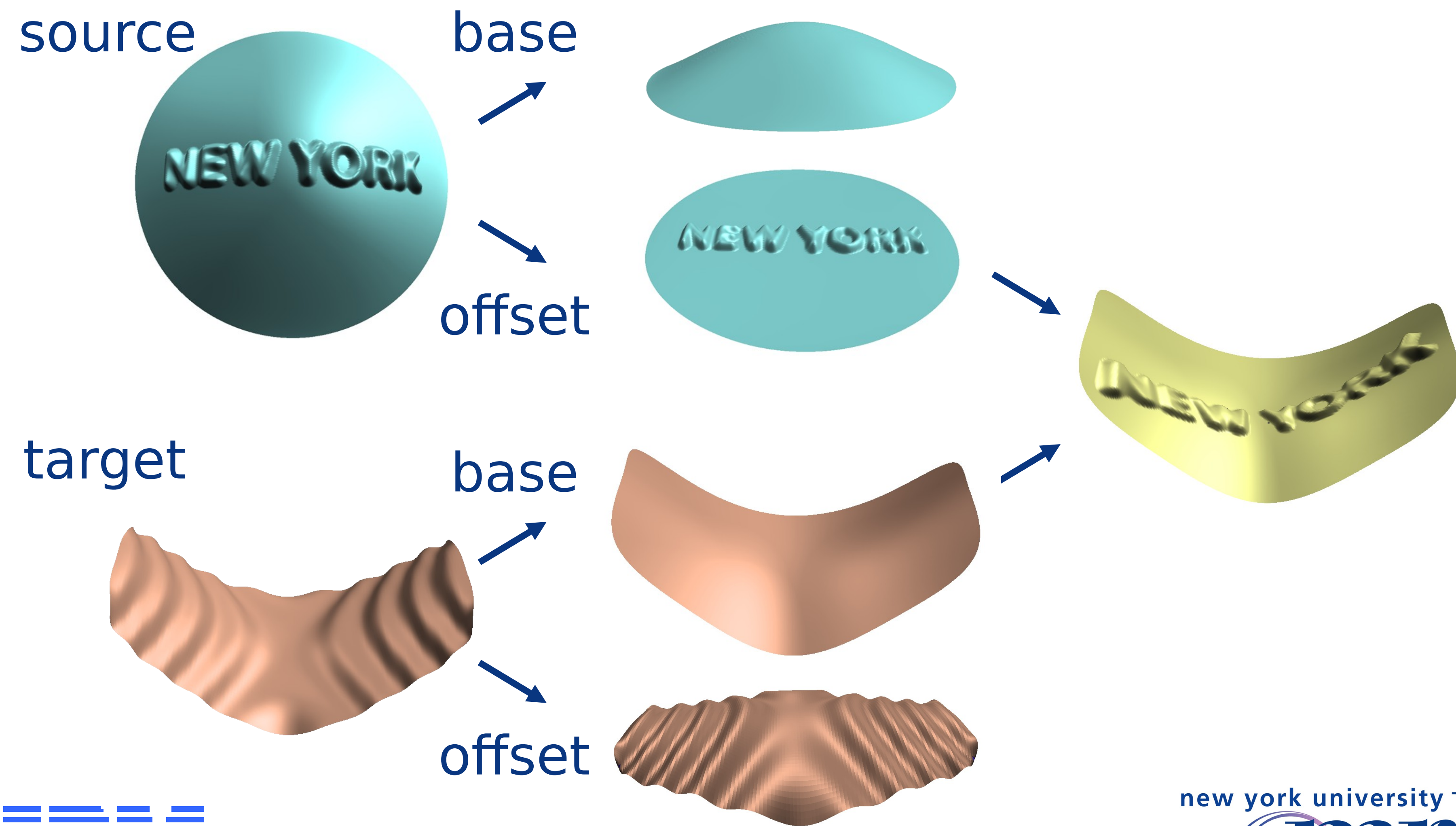
Surface Pasting

- Transfer geometry between surfaces
- Interactive placement

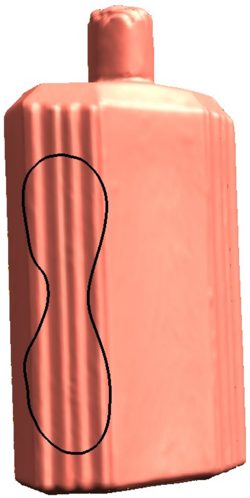


new york university mrl

Approach


source
NEW YORK
base
offset
NEW YORK
NEW YORK
target
base
offset

Algorithm Overview



feature
selectio
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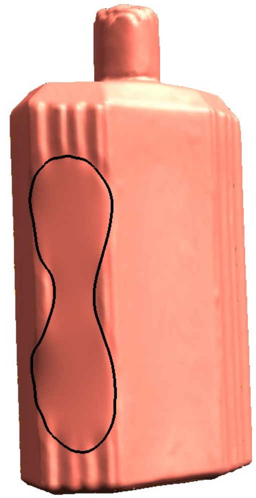

base
surfac
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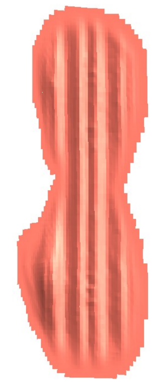
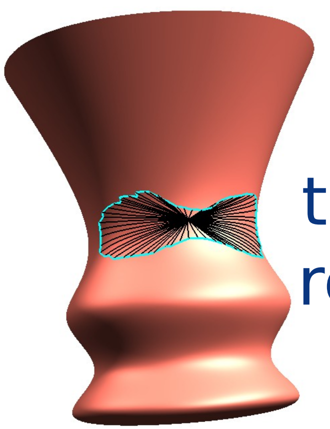
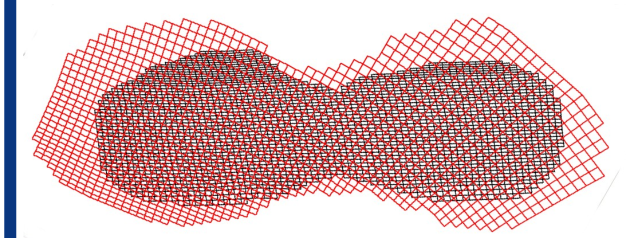


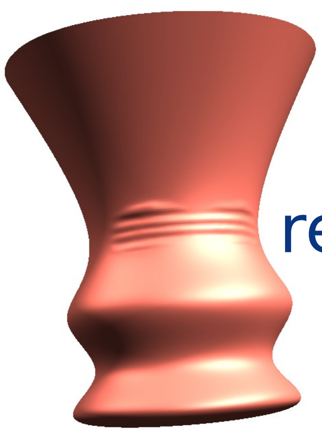
detail
s



target
region



joint
parameterizatio



result

Related Work

Spline pasting

- Forsey [88], Barghiel [95], Mann [97]

Base/detail separation

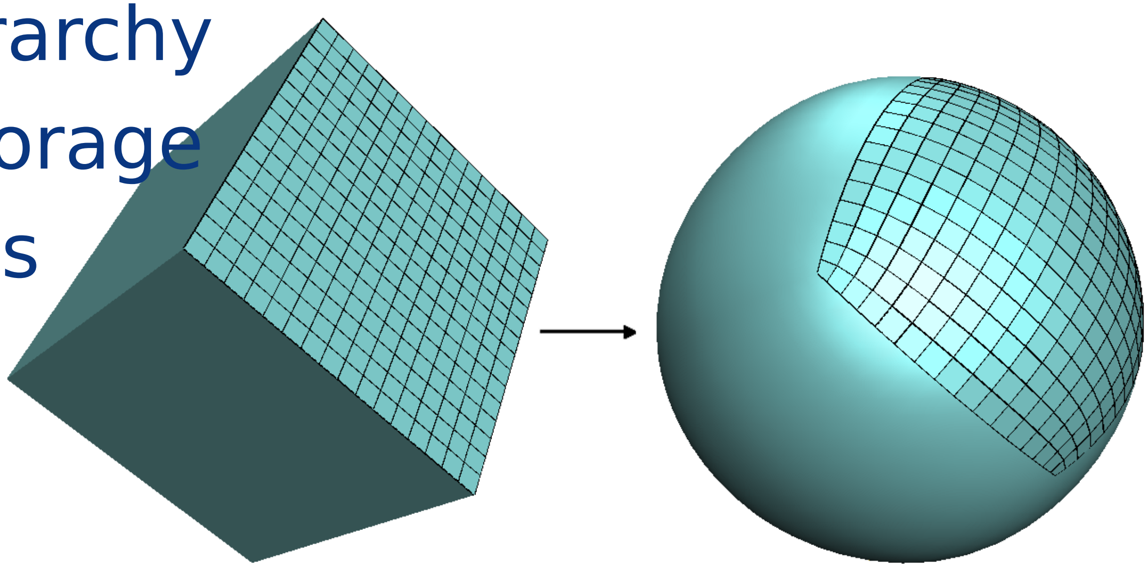
- Kobbelt [98], Guskov [99], Lee [00]

Surface parameterization

- Eck [95], Pedersen [95,96], Floater [97], Guskov [00], Sheffer [00], Desbrun [02], Levy [02]

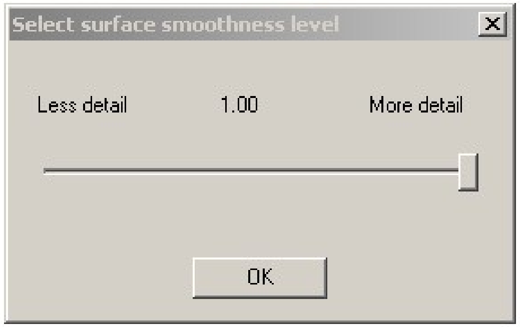
Multiresolution Surfaces

- Efficient algorithms and data structures
  - Natural parameterization
  - Natural hierarchy
  - Compact storage
  - Local frames



Base / Detail Separation

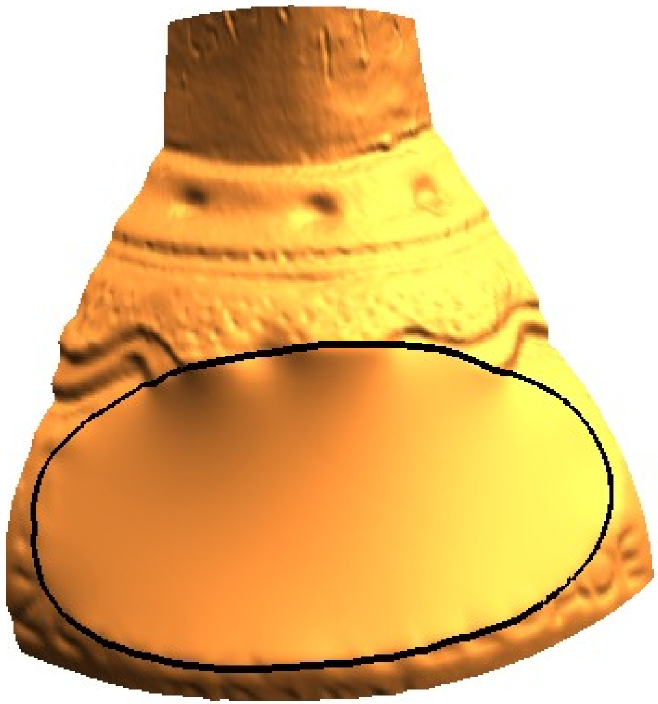
- Controlled by a single parameter: flatness
- Smoothly varying from soapfilm to the original surface
- Use soapfilm surface to get a flatter base than the coarsest level
- Use fitting/quasi-interpolation at different subdivision levels to get discrete set



Family of Base faces

source

target



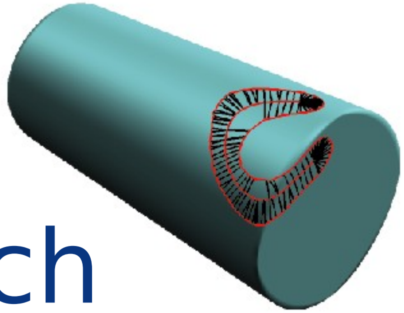
base surface

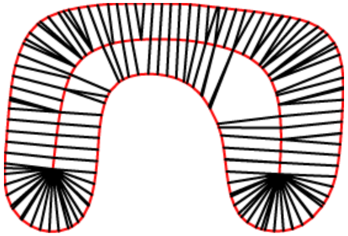
pasting resul

Target Region Finding

Problem

- Find the target region to be parameterized
- Closely match feature size and shape





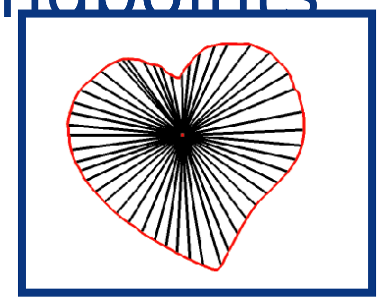
Approach

- Parameterize source boundary w.r.t. a spine
- Transfer the spine to the target surface
- Identify boundary on target, perform flood fill

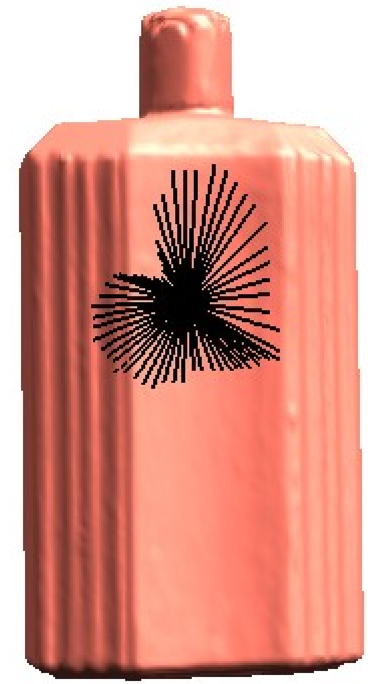
Radial Parameterization

- Source: parameterize feature boundary by angle and distance
- Target: shoot geodesic rays,
  eir endpoints

selected region



radial parameterization



target region

Geodesics

Continuity property:

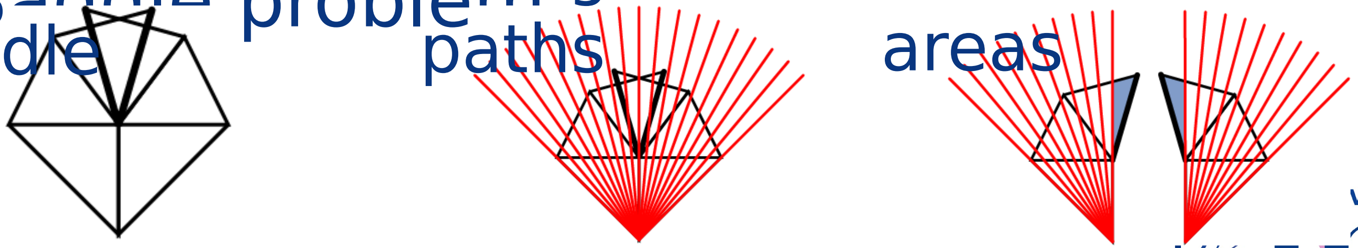
"The distance between the endpoints of two geodesics emanating from the same point can be made arbitrarily small by decreasing the angle between them."

- Not true for straightest geodesics!
- Saddle problem:

flattened saddle

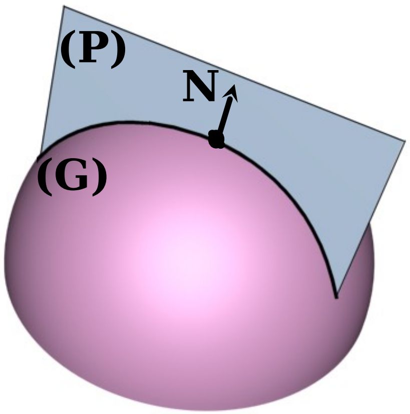
straight paths

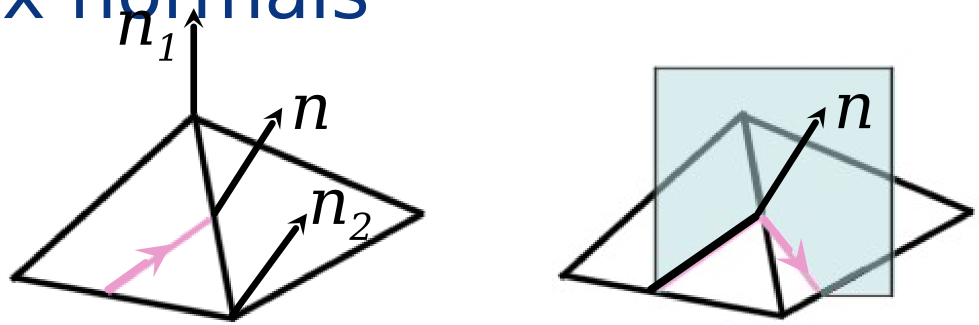
unreachable areas



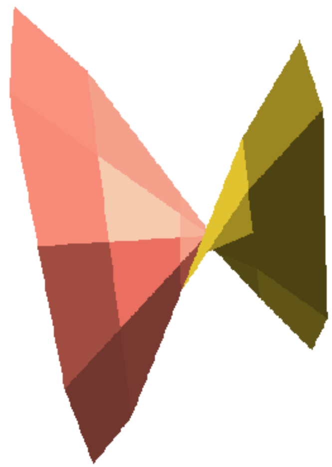
Normal Geodesics

- Geodesics on smooth surfaces are locally normal curves
- Discrete setting: walk from triangle to triangle in a direction perpendicular to the normal interpolated from the vertex normals

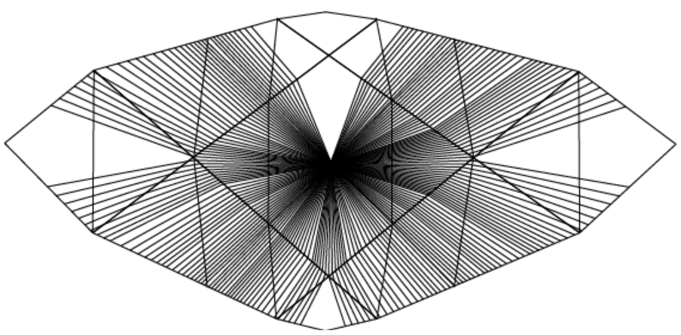




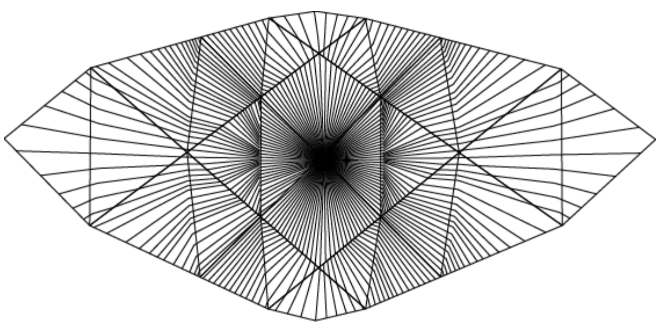
Geodesics



3D saddle mesh



straightest geodesics



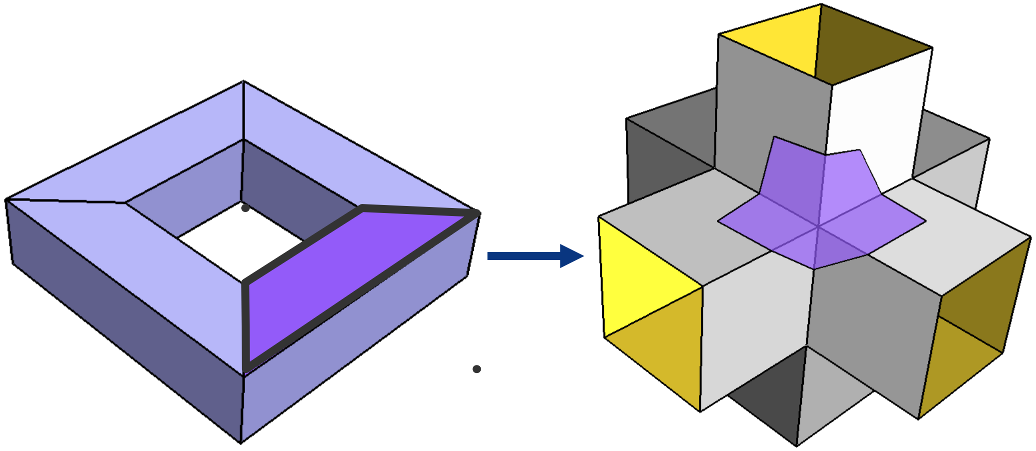
interpolated normal geodesic

Parameterization

Approach: parameterize both source and target onto a plane

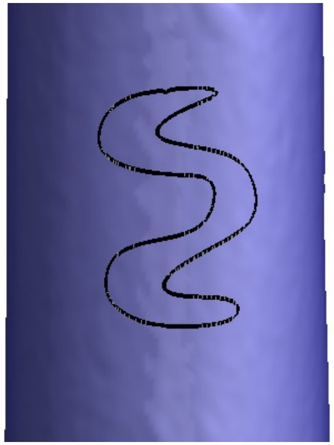
Why use an intermediate plane?

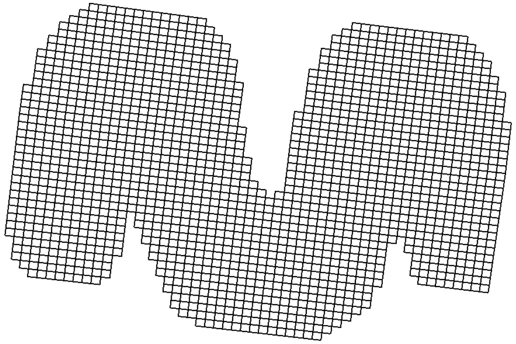
- Direct construction of mapping from surface to surface is difficult
- Quality functionals are difficult to define and expensive to optimize



Requirements

- One-to-one for resampling purposes
- Minimize distortion
- Free boundary





selected feature parameterization

- Until recently, nothing available; now several options: Sheffer ‘00, Desbrun ’02, Levy’02

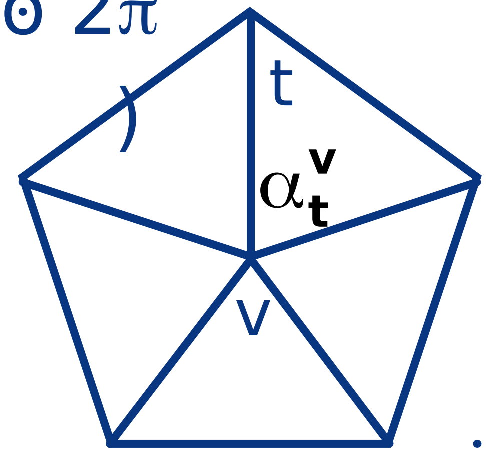
Angle-Based Flattening

(Sheffer & de Sturler'00)

Use angles as variables:

- Set target angles ϕ_t^v so that at each vertex v angles sum up to 2π

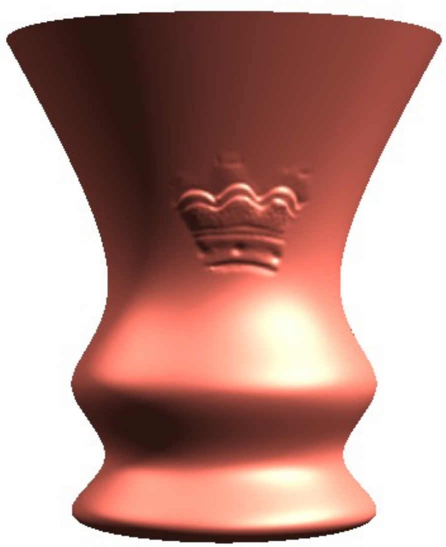
  (scale angles by $2\pi / \sum_t \alpha_t^v$)

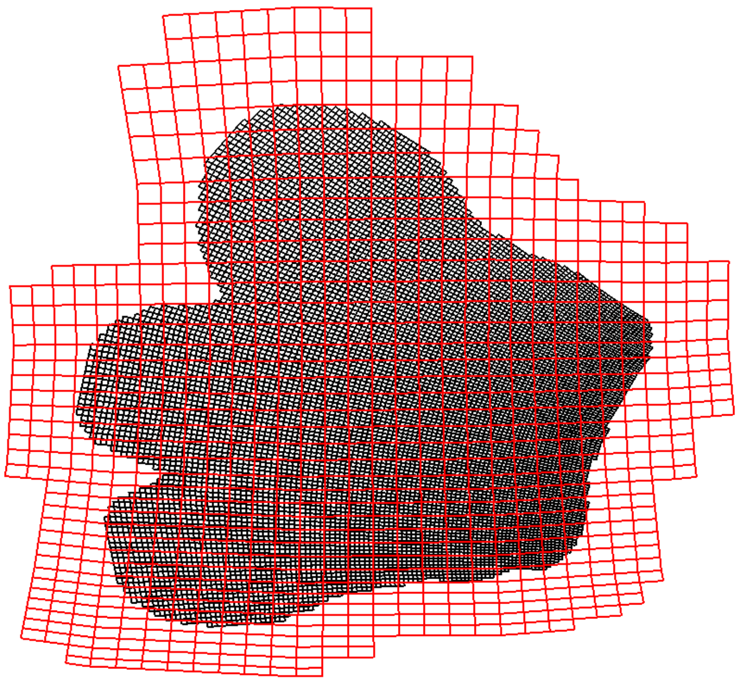


- Optimize $\sum_{t,v} w_t^v \left(\alpha_t^v - \phi_t^v\right)^2$ subject to constraints

Nonlinear Optimization

- The flatter the mesh, the faster it converges
- Use Newton iteration, solve a linear system … Conjugate …



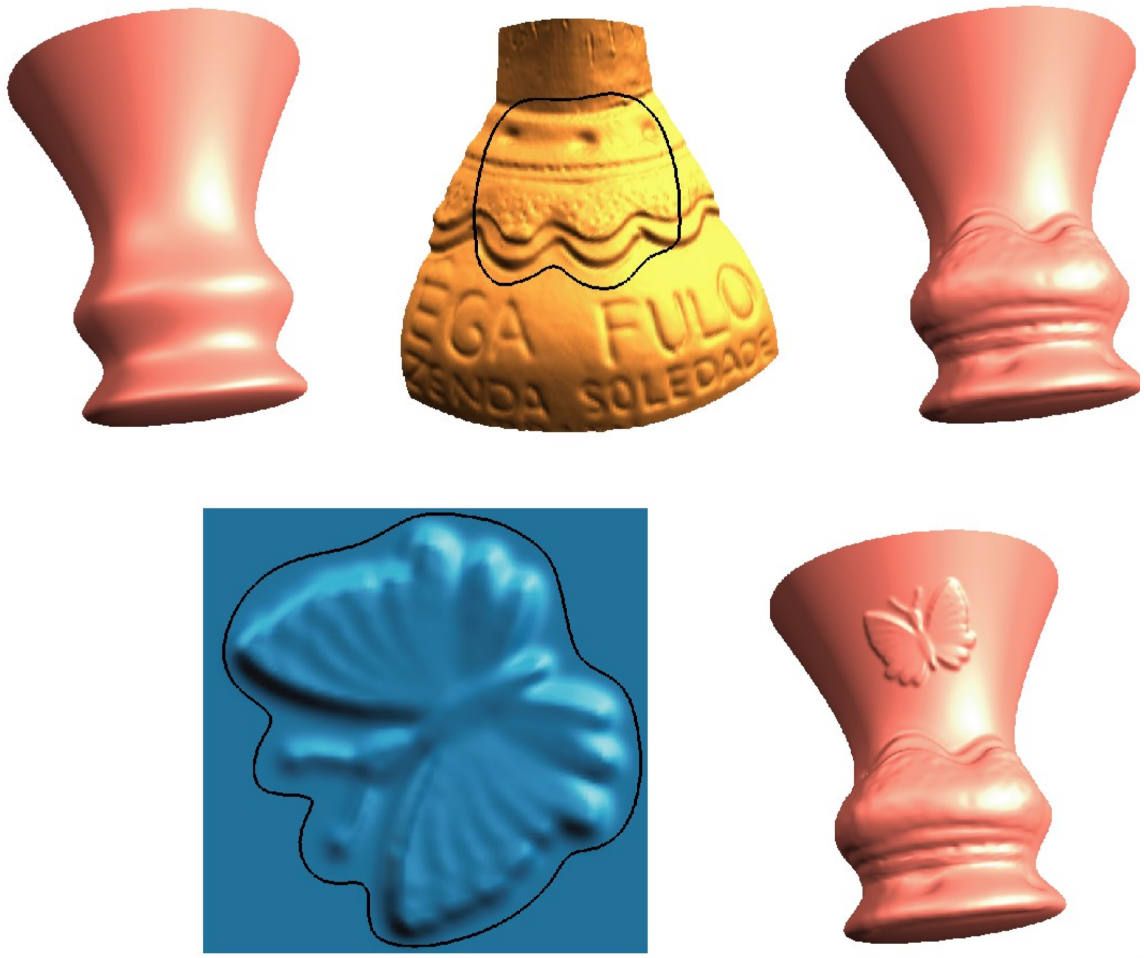


Resampling

On the common parameterization:

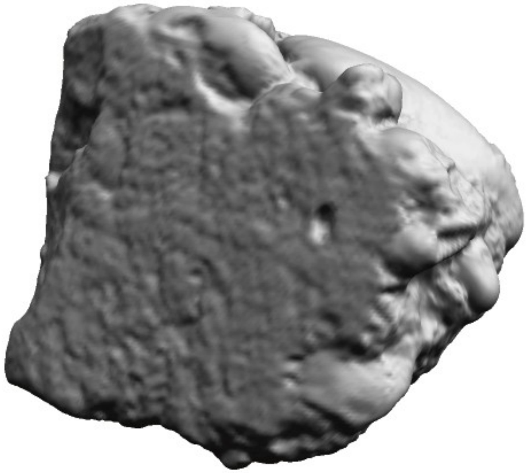
- Resample source details at target vertex positions in parametric domain
- Point location + evaluation (bilinear or subdivision)
- Use differentials to transform details

Examples



Interactive Demo

Examples

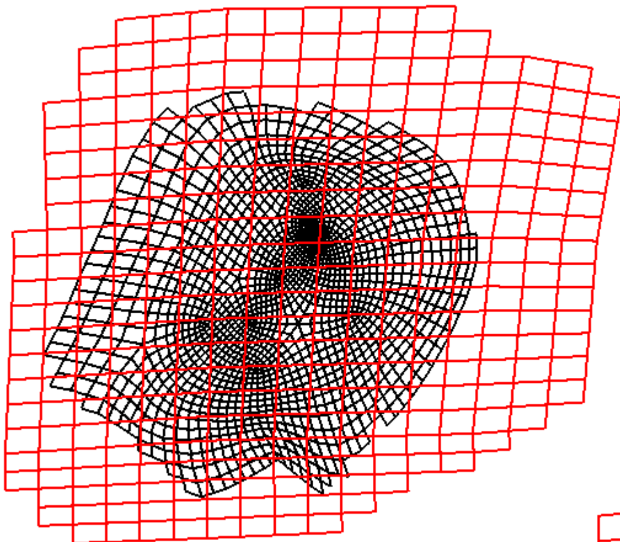


target

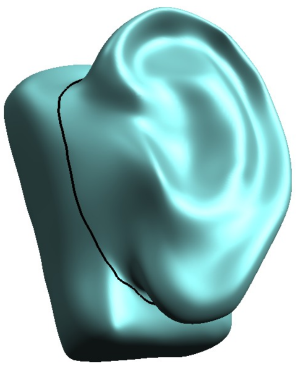
pasting with target details removed

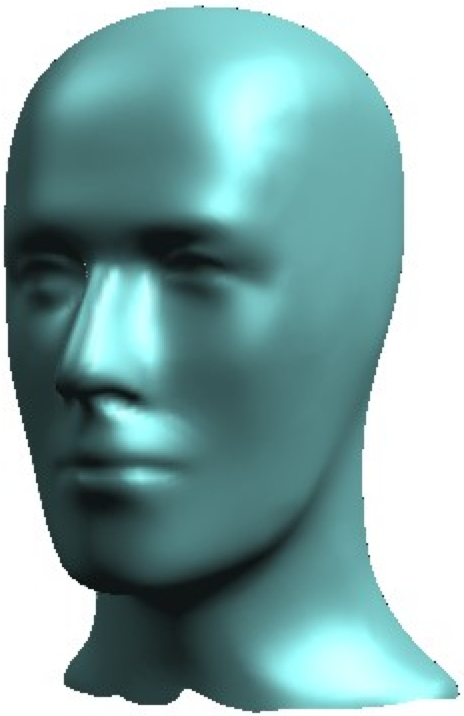
pasting with target details preserved

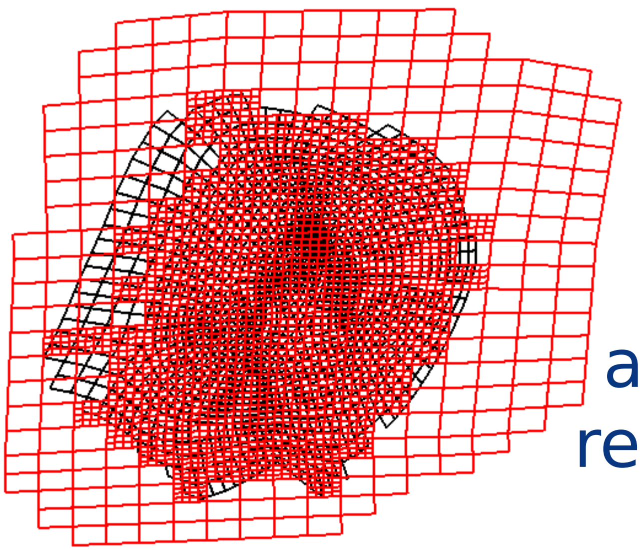
Examples



uniform resampling



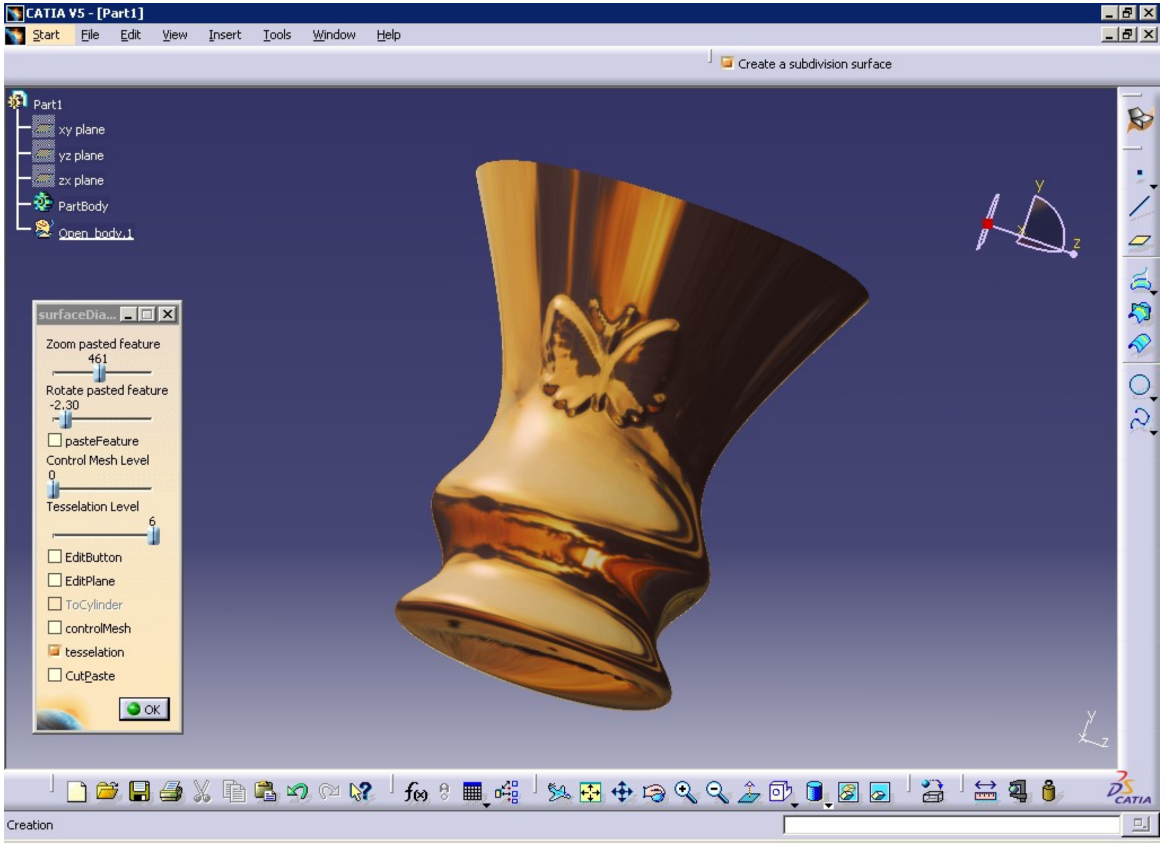




adaptive resampling

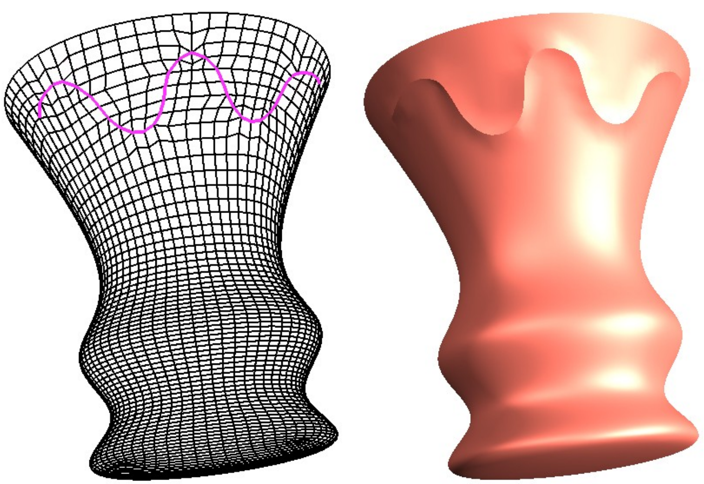
CATIA Integration

- Prototype cut-and-paste functionality in CATIA (Dassault Systemes)



Future Work

- Photoshop-like feature blending
- Combine pasting with texture generation
- Sharp features (Biermann, Martin, Zorin, Bernardini, PG2001, GMOD 02)
- Hierarch



Acknowledgments

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- Dassault Systemes research team

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- NYU Dean’s Fellowship

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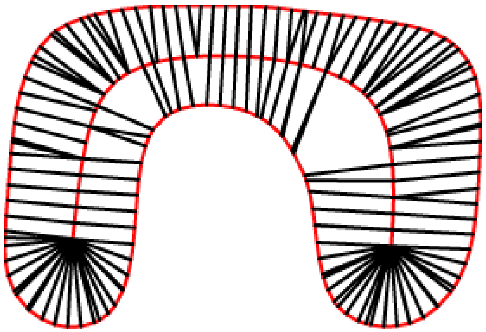
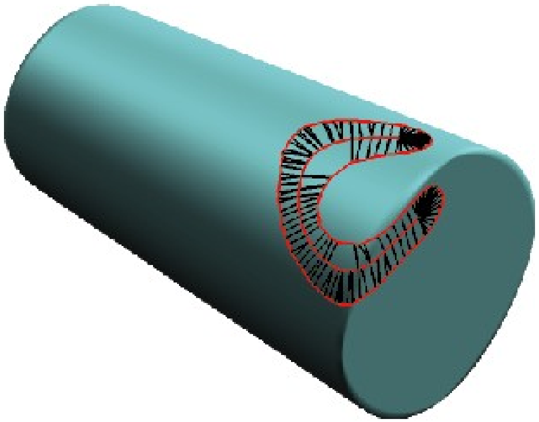
THE END

Generalized Radial Parameterization

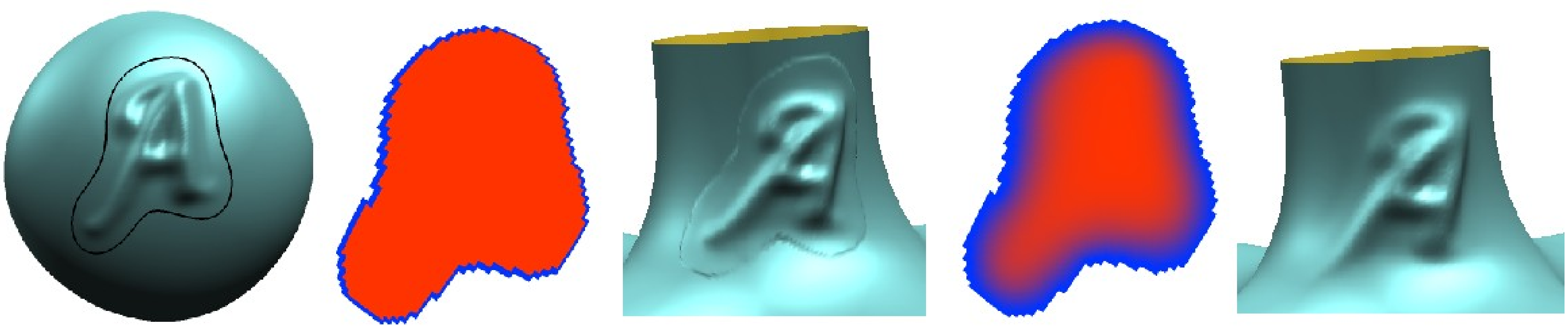
- Start with a spine: parameterize boundary by (spine point, direction, distance)
- Map spine onto target
- Walk along geodesic rays from spine points





Blending

Smooth transition between the pasted feature and the target



feature | original alpha map | pasting w/o blending | smoothed alpha map | past w bler